49. Machærota punctulata, Signoret.

Machærota punctulata, Signoret, A. S. E. F. (5 Sér.), ix. p. xlix. (1879).

Brownish yellow, with the middle of the frons, the abdomen above (except the base), the feet (except the posterior tibiæ), and the frontal grooves, black; several transverse black spots on the thorax which is very finely punctured: metanotum brownish with two yellow, lateral, basal spots, the tip and the process blackish: tegmina elongate, five-celled and above the marginal two to three others smaller, very distinct: the hyaline nervures are spotted with several brown dots. Long 4 millims. ♀.

Reported from Silhat.

Note. *Cosmopsaltria abdulla*, Distant, noticed as No. 57 at page 226 of the Journal for 1884 is the same as *Cosmopsaltria spinosa*, Fabricius, No. 59. The Indian Museum possesses a specimen of *Cosmoscarta siamensis*, Butler, but the locality being uncertain, it has not been entered here.

III.—*On Observations of the Solar Thermometer at Lucknow.—By* S. A. Hill, *B. Sc., A. R. S. M., Meteorological Reporter North-Western Provinces and Oudh.*

[Received 23rd March 1885;—Read 6th May 1885.]

In the volume of this Journal for 1883,* I have discussed some observations of solar radiation made at Allahabad with the ordinary black-bulb maximum thermometer *in vacuo.* The conclusions drawn from these were that the absorbing power of the atmosphere is dependent upon the tension of aqueous vapour and the quantity of dust suspended in the air, pure dry air being very diathermanous; and that, when allowance is made for the variations of aqueous vapour, the mean results for the heating power of the sun during the years 1876—1882 exhibit a very uniform and gradual variation, culminating in 1878 and gradually decreasing afterwards, therefore presumably having an inverse relation to the number of spots on the sun's surface. The resulting variation is so regular in its character that, irrespective of its pointing to a conclusion regarding the sun's heat which is the reverse of that gene-

* Vol. li. Part ii.

rally held by solar physicists, I have always looked upon it as doubtful, and probably due in part to some fortuitous combination of errors. I therefore intend on some future occasion, possibly after the end of the present year, when the position of the thermometer at Allahabad will be changed, to go over the figures again, taking a longer series of observations and making allowance for a cause of variation from month to month, namely, the elliptic form of the earth's orbit, which was neglected in the paper referred to. Meanwhile, I wish to lay before the Society the results of some other observations bearing on the same question, which tend to confirm the conclusions arrived at in my previous paper. To the method by which these results are attained, less exception can be taken, because they are in every case derived from several observations made on the same day under different degrees of obliquity of incidence, instead of upon the single record of a self-registering instrument.

Shortly after hourly observations on four days in each month were commenced at Lucknow, it was discovered that the solar thermometer in use at that station had ceased to be self-registering. A new instrument was therefore brought into use on ordinary days, but the old one was retained for the hourly observations. The records of all such observations of this instrument since the middle of the year 1876 have been filed, but for the purposes of the present paper I have used only those of the eight years 1877—1884 inclusive. At Agra, similar observations of a non-registering solar thermometer have been made for some years on hourly observation days, but, owing to a change of instrument, the register for the years 1877—1884 is broken. For this reason, and because the observatory at Agra is situated in the midst of the city, I have not thought it worth while to reduce the registers of that station, though they seem to confirm in a general way the results obtained from Lucknow.

Those parts of the Lucknow records which have been used for the purposes of the present paper are printed in Table I. The figures represent for each hour of observation the difference between the temperature of the black-bulb thermometer in the sunshine and the simultaneous temperature in the shade. Only those hours are given at which the sky was either quite free from cloud or at which the cloud proportion did not exceed 2-10ths of the expanse. In the months of July and August, very few clear days, thus defined, occur; consequently these months have been left out in drawing up the tables. For every other month in the eight years, except September 1878 and June 1880, there are some observations available.

TABLE I.—*Excess Temperatures of Insolation on clear, or nearly clear, days at Lucknow.*

	Hours of observation, Mean Time.								
	8	9	10	11	12	13	14	15	16
January, 1877...7th	23·9	43·3	51·0	52·1	56·1	...	...	42·4	29·1
14th	41·1	51·0	59·5	...	...	...	...	...	...
21st	41·5	52·5	57·5	60·7	57·8	56·6	53·6	50·1	40·1
28th	...	...	...	...	...	...	...	...	...
February.........7th	...	...	...	...	...	...	...	...	...
14th	42·0	53·8	55·0	57·3	62·8	57·7	55·3	46·4	42·1
21st	...	...	...	...	...	...	...	...	...
28th	44·0	54·1	58·8	59·4	59·6	58·9	55·8	51·1	45·4
March............ 7th	42·0	54·1	58·6	59·1	58·9	58·1	55·1	47·9	39·1
14th	38·1	52·1	58·1	56·1	54·6	54·1	52·6	...	...
21st	...	...	...	...	...	...	...	...	...
28th	...	...	...	...	...	56·1	52·9	49·6	41·9
April 7th	...	...	...	...	...	...	...	...	...
14th	47·1	53·6	57·6	58·1	57·1	55·0	52·8	...	...
21st	48·1	53·1	56·1	56·5	57·0	55·5	54·0	50·7	44·5
28th	...	...	...	...	...	...	...	...	...
May 7th	...	...	...	...	...	...	...	52·1	44·9
14th	...	55·8	55·8	57·0	56·0	57·0	54·5	49·5	42·0
21st	47·3	52·0	55·0	57·7	54·0	...	...	49·5	38·3
28th	40·3	48·3	53·0	57·0	58·0	54·8	55·0	50·0	41·8
June...............7th	...	...	...	...	...	...	...	...	...
14th	42·9	49·5	56·0	55·5	56·7	55·7	55·5	49·0	36·8
21st	38·8	50·0	55·0	...	...	...	...	41·0	35·0
28th	...	...	...	...	...	...	...	...	...
September...... 7th	...	45·9	53·1	...	57·3	...	...	...	...
14th	38·4	47·9	50·0	56·5	56·0	...	...	...	...
21st	40·9	47·8	49·3	51·8	53·8	...	...	...	...
28th	37·1	45·1	46·5	53·3	54·0	...	51·0	47·0	35·5
October......... 7th	...	...	...	...	...	...	...	...	...
14th	43·6	48·9	53·6	55·4	56·1	54·4	50·3	45·1	35·1
21st	38·1	43·6	46·4	48·1	50·1	48.6	...	...	32·1
28th	40·1	46·4	54·6	56·4	56·4	52.6	48·6	41·6	29·6
November 7th	...	...	...	...	...	...	...	...	...
14th	35·7	49·4	...	58·1	58·1	55·6	54·1	47·4	18·6
21st	...	44·1	51·4	56·4	57·9	57·6	50·4	44·3	20·3
28th	...	...	...	...	...	...	...	...	...
December 7th	...	...	...	...	...	...	...	...	...
14th	41·5	52·3	56·3	54·5	53·5	52·0	48·5	44·7	11·0
21st	39·3	47·0	...	...	...	48·0	40·8	32·8	12·3
28th	...	...	...	...	...	...	...	...	...

	Hours of observation, Mean Time.								
	8	9	10	11	12	13	14	15	16
January, 1878...7th	34·8	45·1	49·3	47·5	47·0	46·0	41·0	32·0	...
14th	...	...	...	...	...	...	...	...	...
21st	29·0	48·5	55·0	56·0	53·0	43·6	42·1	39·0	...
28th	...	...	...	...	...	...	...	...	...
February.........7th	...	...	...	...	...	...	...	...	...
14th	42·3	53·0	60·3	59·5	59·9	61·1	58·9	51·4	40·6
21st	...	...	...	...	...	...	...	...	...
28th	35·0	46·0	60·0	61·6	64·1	62·1	60·1	46·9	37·4
March............ 7th	45·5	57·1	60·1	61·9	66·1	65·1	60·1	46·1	39·1
14th	45·4	...	...	...	...	65·5	59·0	52·0	...
21st	...	...	...	...	...	...	...	...	...
28th	...	...	...	57·3	58·0	53·0	52·0	46·5	36·0
April 7th	...	...	...	...	...	...	...	...	...
14th	...	...	50·1	56·1	57·1	57·1	...	...	...
21st	48·1	55·1	61·0	...	...	...	...	...	...
28th	46·6	58·6	65·8	...	...	...	...	...	...
May 7th	...	...	...	...	...	56·6	52·0	44·8	33·0
14th	43·1	51·4	56·1	54·6	...	...	...	...	...
21st	...	...	...	...	...	60·1	57·0	53·6	...
28th	52·4	56·6	59·8	59·5	63·0	61·5	58·5	52·0	44·5
June...............7th	41·0	51·8	57·0	59·0	61·0	55·0	47·5	45·0	28·5
14th	48·8	51·0	55·5	56·0	...	...	...	43·0	32·5
21st	45·1	52·0	54·0	56·0	57·3	55·5	50·0	42·0	35·0
28th	...	...	...	...	...	...	...	...	...
September 7th	...	...	...	...	...	...	...	...	...
14th	...	...	...	...	...	...	...	...	...
21st	...	...	...	...	...	...	...	...	...
28th	...	...	...	...	...	...	...	...	...
October 7th	39·6	50·9	53·4	57·1	58·6	55·5	53·0	46·0	32·5
14th	37·1	47·1	54·1	58·9	59·4	58·6	57·0	47·0	44·1
21st	44·6	48·1	55·1	55·6	56·0	57·0	54·0	44·8	35·0
28th	39·5	47·6	52·4	55·9	54·9	52·6	50·6	31·1	24·9
November 7th	...	...	...	...	...	...	...	...	...
14th	...	...	...	...	...	...	...	...	...
21st	...	...	...	...	...	...	...	...	...
28th	35·5	47·5	50·1	52·6	54·9	55·1	48·6	40·1	29·9
December 7th	44·0	51·5	54·1	55·9	57·6	45·1	40·9	32·6	...
14th	37·1	40·0	47·5	49·1	49·4	46·4	43·6	37·6	...
21st	40·6	47·5	59·5	58·5	56·1	51·1	41·5	35·5	77·0
28th	...	...	...	...	...	...	...	...	...

	Hours of observation, Mean Time.								
	8	9	10	11	12	13	14	15	16
January, 1879...7th	30·1	46·8	55·0	...	...	...	...	...	...
14th	31·8	56·0	53·0	53·1	52·4	51·4	49·1	40·1	30·4
21st	36·1	55·5	57·0	59·6	55·4	47·6	44·4	38·1	28·6
28th	35·6	50·3	54·3	50·6	50·1	49·1	42·1	41·1	25·1
February......... 7th	41·7	...	59·5	55·1	52·1	51·4	43·9	44·1	40·1
14th	...	...	...	...	...	...	...	...	...
21st	45·0	48·9	60·1	56·4	55·9	54·6	53·1	...	45·1
28th	42·3	53·4	58·6	56·1	55·4	53·9	52·6	49·1	29·6
March 7th	...	...	...	57·6	56·6	54·6	...	...	44·6
14th	...	49·1	59·9	...	...	...	...	...	...
21st	52·6	56·1	63·1	62·1	61·1	58·1	54·9	43·1	41·9
28th	44·9	52·6	58·5	59·0	55·0	54·0	48·0	44·5	40·3
April 7th	47·1	50·8	59·5	60·8	62·8	62·8	59·6	...	...
14th	48·9	56·5	59·5	60·3	60·8	60·5	55·8	51·3	40·8
21st	...	...	...	...	...	...	...	...	...
28th	43·8	56·0	61·0	61·8	62·0	61·8	54·8	47·5	46·5
May 7th	44·1	53·0	57·0	55·0	58·3	57·5	55·5	48·5	38·5
14th	43·5	52·0	60·0	62·0	62·3	60·8	57·3	44·5	41·5
21st	...	...	...	...	...	...	...	...	...
28th	41·4	52·6	63·5	62·0	61·0	...	...	...	...
June............... 7th	36·1	45·9	56·0	55·0	56·0	47·5	42·5	...	...
14th	38·8	52·5	56·5	58·3	60·0	59·5	57·5	39·8	27·0
21st	...	...	...	...	...	...	...	...	...
28th	...	...	...	...	...	...	...	...	...
September 7th	...	...	...	...	...	...	...	...	...
14th	37·3	46·1	53·6	52·9	51·1	49·1	43·1	39·1	34·1
21st	...	...	...	...	...	...	...	...	...
28th	...	...	...	...	...	...	...	...	...
October 7th	...	...	...	...	...	...	...	...	...
14th	45·1	51·1	50·6	52·6	49·6	47·6	46·1	40·6	32·6
21st	41·1	55·6	59·1	59·9	56·6	50·1	46·1	36·1	28·1
28th	49·6	55·2	59·9	59·0	56·1	52·4	43·1	32·6	29·1
November 7th	39·3	54·2	58·7	59·4	53·6	46·1	40·1	36·8	21·4
14th	35·7	52·4	57·8	48·6	47·6	44·2	39·6	36·7	28·6
21st	45·5	53·4	56·5	49·2	45·6	41·4	38·8	34·2	24·9
28th	41·5	58·3	57·3	50·7	46·2	41·2	35·1	25·9	11·6
December 7th	37·9	55·5	59·7	49·6	48·4	46·6	42·3	35·9	7·4
14th	32·9	48·5	55·0	49·5	47·6	38·9	36·1	33·9	22·5
21st	36·0	44·5	56·5	52·6	47·1	45·1	41·4	32·2	18·9
28th	...	...	...	...	...	...	...	...	...

	Hours of observation, Mean Time.								
	8	9	10	11	12	13	14	15	16
January, 1880...7th	43·3	53·0	57·9	49·5	49·4	49·6	43·1	37·6	25·6
14th	36·6	50·7	54·8	49·7	50·6	47·6	43·6	37·8	32·0
21st	...	...	...	...	...	...	...	...	...
28th	...	...	...	...	...	...	...	...	...
February......... 7th	42·0	50·5	57·5	51·0	51·9	50·4	47·6	43·1	34·6
14th	...	...	...	...	...	...	...	...	...
21st	43·8	54·7	59·9	56·3	54·6	52·6	50·4	47·8	41·8
28th	38·1	57·4	61·0	56·6	54·5	52·0	49·1	44·1	37·6
March............ 7th	28·0	47·6	55·4	53·6	53·9	49·1	46·8	47·8	31·9
14th	33·6	49·4	58·1	56·0	54·8	52·8	49·8	44·8	34·8
21st	39·6	47·0	52·2	49·6	55·8	53·8	46·8	41·8	39·3
28th	38·6	47·6	54·1	55·8	56·6	53·8	52·0	51·3	43·3
April 7th	43·6	50·6	54·1	...	...	...	...	...	40·8
14th	...	...	...	...	...	...	...	...	...
21st	...	...	...	...	...	...	...	...	...
28th	...	...	...	...	53·0	50·8	52·8	47·8	40·6
May............... 7th	45·6	53·1	56·6	56·8	55·6	54·1	52·2	48·3	42·8
14th	...	...	...	...	...	...	...	...	...
21st	...	...	...	...	...	...	...	...	...
28th	38·5	49·3	51·8	52·8	52·8	54·8	54·8	51·2	42·8
June............... 7th	...	...	...	...	...	...	...	...	...
14th	...	...	...	...	...	...	...	...	...
21st	...	...	...	...	...	...	...	...	...
28th	...	...	...	...	...	...	...	...	...
September 7th	...	...	...	...	...	...	...	...	...
14th	...	...	...	...	...	...	...	...	...
21st	45·1	50·0	56·1	...	...	...	...	...	...
28th	...	...	...	...	...	...	...	...	...
October 7th	28·6	47·1	54·1	59·1	56·0	54·2	45·8	42·9	38·6
14th	41·4	49·9	57·6	59·6	58·8	58·6	55·8	52·3	...
21st	44·6	52·1	52·6	56·4	58·7	56·4	54·3	45·6	29·8
28th	46·6	53·6	62·6	62·9	66·6	62·7	59·7	51·6	...
November 7th	39·6	51·1	54·1	57·1	46·6	45·6	...	...	...
14th	42·0	50·5	53·6	53·6	46·1	45·6	46·6	39·1	28·6
21st	...	...	...	...	...	...	...	...	...
28th	...	52·8	56·8	53·1	50·8	50·1	41·9	36·4	23·2
December 7th	35·7	48·0	55·6	...	...	55·6	54·1	...	...
14th	36·0	46·5	...	...	56·6	47·0	...	34·6	25·6
21st	...	...	...	...	52·0	47·5	43·6	35·6	27·5
28th	36·6	46·3	65·1	56·1	49·6	...	...	...	27·1

	Hours of observation, Mean Time.								
	8	9	10	11	12	13	14	15	16
January, 1881...7th	...	...	...	49·8	53·5	56·7	49·9	46·6	28·0
14th	38·6	50·8	54·0	52·5	49·9	50·1	42·6	38·6	29·1
21st	34·6	51·5	59·0	57·0	54·1	52·9	48·8	41·1	31·9
28th	54·3	60·8	64·3	70·7	74·7	77·2	...	...	...
February 7th	37·5	52·5	55·5	53·6	54·6	54·6	53·1	47·6	39·6
14th	33·5	52·0	52·6	56·1	55·1	53·6	52·1	46·7	...
21st	...	...	...	...	...	...	...	...	...
28th	29·5	52·6	57·1	57·1	57·6	...	...	...	...
March............ 7th	...	...	...	...	...	...	...	...	...
14th	...	...	...	...	...	...	...	...	...
21st	45·5	55·8	59·1	...	...	...	...	...	...
28th	44·5	51·6	57·1	...	...	...	...	...	...
April 7th	...	...	...	...	...	...	...	...	...
14th	45·6	53·9	56·9	54·8	55·3	54·8	52·8	...	58·3
21st	40·7	48·0	55·1	56·1	55·9	55·3	51·9	...	43·8
28th	46·4	47·6	57·6	58·3	55·8	52·6	50·3	45·3	33·8
May............... 7th	40·1	47·6	52·8	53·8	54·3	53·3	49·8	44·8	36·2
14th	...	...	...	...	...	...	...	...	...
21st	37·5	47·8	52·3	53·6	55·3	54·6	53·6	...	...
28th	41·1	48·3	53·3	57·6	54·6	51·8	...	...	...
June 7th	32·3	39·3	42·3	...	...	...	...	...	...
14th	...	...	...	...	...	...	...	...	...
21st	...	...	...	...	...	...	...	...	...
28th	...	...	...	...	...	...	...	...	...
September...... 7th	...	...	...	...	...	...	...	...	...
14th	...	...	...	...	...	...	...	...	...
21st	...	...	...	...	...	...	...	...	...
28th	41·8	52·8	56·8	54·4	53·8	53·3	...	...	42·3
October 7th	...	...	...	...	...	...	...	...	...
14th	42·6	51·7	54·6	54·9	54·3	51·3	47·3	40·3	30·8
21st	48·6	52·6	53·8	51·8	53·3	51·3	43·6	35·3	29·1
28th	...	...	...	51·9	53·9	49·4	49·1	44·9	26·5
November 7th	...	...	...	...	...	48·1	45·1	38·6	22·1
14th	47·3	54·1	58·6	52·9	53·6	50·6	43·8	40·9	19·6
21st	42·9	51·3	55·6	56·6	54·1	49·6	43·7	38·1	26·6
28th	42·8	49·7	54·1	47·1	45·6	40·9	36·1	34·1	21·6
December 7th	35·5	48·8	52·0	52·4	52·9	47·9	43·4	31·6	21·4
14th	45·0	51·5	53·5	50·4	46·6	42·6	43·4	30·1	17·6
21st	29·8	50·0	55·5	50·1	47·6	43·6	32·1	27·6	17·6
28th	38·8	51·3	54·5	55·9	54·1	49·8	43·1	34·6	23·1

	Hours of observation, Mean Time.								
	8	9	10	11	12	13	14	15	16
January, 1882...7th	33·5	49·8	54·5	55·0	53·7	50·6	48·1	44·1	32·1
14th	35·3	38·2	52·5	55·5	55·5	51·0	45·9	41·4	...
21st	29·5	42·3	51·5	54·5	55·8	51·6	47·1	38·6	32·4
28th	42·5	44·5	55·6	57·6	...	49·4	...	38·4	33·1
February 7th	45·5	52·5	59·4	61·1	59·1	56·9	50·6	42·6	33·4
14th	...	...	...	...	...	49·6	44·4	39·9	28·4
21st	45·5	56·7	62·5	60·6	61·6	59·9	57·4	53·6	44·6
28th	31·5	48·1	61·1	56·6	56·6	55·1	52·1	46·9	37·6
March 7th	39·3	51·6	57·1	55·1	54·8	50·8	...	...	...
14th	...	...	...	...	...	...	...	...	...
21st	50·6	53·4	58·6	59·3	56·8	54·3	51·8	42·6	23·3
28th	40·6	48·8	55·6	55·9	57·8	58·8	53·8	47·3	39·6
April 7th	...	...	...	...	...	...	...	...	...
14th	45·6	53·6	56·8	59·8	59·0	54·6	52·8	48·3	41·3
21st	...	...	...	...	...	...	...	...	...
28th	44·2	53·0	58·3	59·8	56·6	51·8	49·3	46·8	40·3
May 7th	51·6	54·9	56·6	...	...	...	...	...	...
14th	...	...	...	...	...	...	...	...	...
21st	45·8	54·8	56·3	59·8	55·3	51·8	46·3	41·8	39·8
28th	...	...	...	...	...	...	...	...	...
June 7th	...	...	...	...	...	...	...	...	...
14th	...	...	...	...	...	...	...	...	...
21st	42·6	47·4	...	...	...	...	49·8	43·3	...
28th	...	...	...	...	...	...	...	...	...
September...... 7th	35·6	48·6	53·1	...	...	...	...	...	...
14th	...	...	...	...	...	...	...	...	...
21st	...	...	...	...	...	...	...	...	...
28th	52·1	52·4	52·1	47·8	50·8	50·8	46·3	40·8	30·5
October 7th	...	...	...	...	...	...	...	...	...
14th	37·6	46·6	51·1	51·1	49·8	44·3	40·3	32·5	26·8
21st	46·6	51·0	53·6	54·6	48·6	46·3	41·3	35·8	23·8
28th	39·9	49·6	50·4	49·9	48·1	42·6	39·1	36·6	18·6
November 7th	45·2	48·1	50·4	50·6	47·1	41·9	38·1	30·9	13·6
14th	40·2	45·1	51·9	50·3	45·6	41·6	37·6	30·9	15·1
21st	37·5	50·5	54·1	51·4	46·6	42·1	36·1	26·1	12·1
28th	...	...	...	...	...	...	...	...	...
December 7th	31·2	46·5	51·1	51·6	49·6	43·1	37·1	27·6	18·1
14th	35·3	45·5	48·6	47·6	44·9	41·1	36·1	26·1	18·6
21st	...	...	...	...	...	...	...	...	...
28th	43·5	55·5	55·5	54·6	51·1	45·6	37·6	27·1	15·6

	Hours of observation, Mean Time.								
	8	9	10	11	12	13	14	15	16
January, 1883...7th	27·8	40·8	47·0	48·4	...	...	...	...	...
14th	34·5	49·5	52·5	52·1	50·6	46·4	38·6	31·6	22·6
21st	...	...	...	...	...	...	...	...	...
28th	31·5	47·5	54·0	54·5	50·5	48·5	41·5	35·0	28·0
February 7th	41·1	50·8	55·0	56·0	54·5	48·6	43·6	39·4	31·6
14th	36·5	52·0	55·0	55·6	54·1	50·0	46·9	36·6	32·6
21st	37·5	53·5	54·4	54·9	53·1	50·1	46·1	...	...
28th	...	...	...	...	...	...	...	...	...
March............ 7th	...	...	...	...	...	...	...	...	...
14th	...	...	...	...	...	...	...	...	...
21st	34·6	46·6	55·6	55·6	56·1	52·1	48·9	41·6	...
28th	40·6	50·6	52·6	55·3	54·1	50·8	46·8	...	...
April 7th	43·6	53·6	55·1	56·3	54·3	50·8	46·8	41·3	39·8
14th	...	...	...	...	...	...	...	...	...
21st	48·2	53·8	56·1	55·8	55·6	54·3	48·1	44·3	37·8
28th	37·6	49·6	53·6	55·6	55·8	...	48·8	41·8	33·1
May.............. 7th	43·8	50·8	54·8	55·8	54·8	52·3	47·8	45·3	36·8
14th	36·6	54·8	56·8	54·8	53·1	50·5	49·5	46·3	...
21st	30·6	43·6	44·8	48·8	55·6	56·3	49·8	44·8	31·8
28th	...	...	...	...	...	...	...	...	...
June 7th	36·1	50·8	53·8	55·6	52·8	49·8	46·3	46·8	36·8
14th	...	...	...	...	...	...	...	...	...
21st	...	...	...	...	...	...	...	...	...
28th	...	...	...	...	...	...	...	...	...
September 7th	44·1	48·6	...	...	54·8	51·8	47·8	...	...
14th	...	...	...	...	...	...	...	...	...
21st	...	...	...	...	...	...	...	...	...
28th	...	...	52·9	52·0	51·3	47·8	44·3	38·8	30·8
October 7th	...	...	...	...	...	...	...	...	...
14th	43·1	46·9	48·6	50·6	52·8	53·8	46·8	35·8	21·6
21st	50·6	53·8	53·6	53·4	53·1	55·1	48·4	45·6	28·6
28th	43·5	48·1	51·1	51·6	54·1	54·6	46·1	41·4	22·6
November 7th	...	...	...	...	...	...	...	...	...
14th	29·6	37·1	42·6	48·6	52·6	...	...	...	...
21st	32·5	41·5	53·5	52·1	56·6	58·6	...	...	...
28th	49·5	50·5	47·6	51·6	50·6	45·1	...	...	...
December 7th	...	40·5	40·5	44·4	45·1	45·6	36·1	22·6	...
14th	...	...	47·5	48·1	48·6	44·6	35·6	28·6	...
21st	...	52·0	53·5	62·0	60·6	47·6	35·6	22·1	...
28th	...	36·5	47·5	58·5	56·1	53·6	48·6	40·6	...

	Hours of observation, Mean Time.								
	8	9	10	11	12	13	14	15	16
January, 1884...7th	30·5	51·5	55·5	53·9	51·3	48·6	42·6	34·1	19·6
14th	50·6	53·5	52·5	46·6	40·6	35·6	29·6	27·1	18·6
21st	27·5	39·5	54·5	50·5	50 6	51·6	39·6	30·4	20·1
28th	22·5	31·5	...	47·8	53·8	50·9	50 1	45·6	...
February 7th	36·5	42·5	48·5	48·0	53·5	52·8	48·1	45·6	39·6
14th	29·5	35·0	38·6	43·6	47·4	52·6	50·4	44·6	24·6
21st	31·5	47·0	53·6	54·6	54·6	56·9	...	...	...
28th	...	...	48·6	50·3	51·6	53·8	49·8	...	...
March............ 7th	30·9	44·6	50·6	48·6	48·9	53·1	48·8	41·6	32·1
14th	...	...	...	...	...	...	...	...	...
21st	...	...	...	...	...	...	...	...	...
28th	52·6	58·6	58·8	61·8	61·8	62·8	54·3	48·8	40·8
April 7th	41·1	52·6	58·6	62·8	64·8	65·8	59·8	48·8	34·3
14th	43·1	52·3	46·8	47·8	48·8	49·8	50·8	49·8	46·8
21st	...	...	...	...	...	...	...	...	...
28th	46·6	56·6	58·8	58·3	57·8	54·6	52·6	46·8	38·8
May 7th	...	...	...	...	...	...	...	...	...
14th	51·8	55·8	55·8	54·8	54·8	45·6	40·8	37·8	35·8
21st	50·6	54·8	57.8	57·8	54·8	52·8	50·8	47·8	40·3
28th	48·8	54·7	57·7	55·7	53·8	51·8	42·8	37·8	35·8
Juue 7th	33·6	45·8	44·8	45·3	44·8	45·8	...	...	41·8
14th	...	...	...	...	...	...	36·8	35·8	25·8
21st	41·6	...	...	45·8	43·8	...	...	...	...
28th	...	...	...	...	...	...	...	...	...
September...... 7th	...	...	...	...	...	...	...	...	...
14th	...	...	...	...	...	...	...	...	...
21st	15·1	34·6	54·8	53·8	54·8	55·8	51·8	44·1	38·8
28th	...	...	...	...	...	...	...	...	...
October 7th	38·6	42·6	51·6	52·6	53·6	52·6	43·6	33·6	27·6
14th	40·6	47·6	51·6	53·4	50·6	49·6	45·6	34·6	28·6
21st	39·6	46·6	50·6	49·6	47·6	46·6	44·6	33·6	11.6
28th	39·6	47·6	51·6	50·6	45·6	41·6	38·6	24·6	9·6
November 7th	38·5	43·5	52·6	53·6	53·6	45·6	41·6	24·6	22·6
14th	35·5	47·5	50·6	49·6	47·6	45·6	44·6	28·6	12·6
21st	24·5	44·5	49·9	52·6	49·6	46·6	43·6	23·6	17·6
28th	39·5	41·5	48·6	48·6	50·6	49·6	47·6	48·6	14·6
December 7th	39·5	52·5	48·5	44·6	42·6	43·6	34·6	27·6	22·6
14th	43·5	52·5	48·5	51·6	45·6	40·6	24·6	9·6	7·9
21st	18·0	24·5	47·5	...	51·6	50·6	50·6	42·5	...
28th	...	...	...	...	...	...	...	...	...

The differences between the numbers given in the table depend primarily upon variations in the sun's incident heat and in the proportion of this which is absorbed before reaching the instrument, the latter being dependent upon the composition of the atmosphere and the obliquity of the rays. Minor causes of variation depend upon the instrument itself and the nature of its surroundings, and upon the reflexion of heat from cloud, haze, or dust particles in the air; the instrument being designed to receive rays coming from all directions and not parallel rays only.

As regards the instrument itself, if its thermal capacity be large, it will be sluggish in responding to any change in the incident radiation. This will cause the incident heat in the afternoon to appear greater than in the forenoon. The Lucknow observations are not appreciably affected with any error of this sort, since the thermometer is a small one with a bulb not much larger than a pea and a tube so fine in bore as to make it easy to estimate tenths of a degree Fahrenheit in reading it. It would, therefore, respond almost instantaneously to any change in the incident radiation, were it not that owing to friction in the narrow tube the mercurial column seems to rise and fall by slight jumps and starts. Observations made at equal hour angles before and after noon may be expected, however, when combined, to eliminate any error due to the sluggishness or *per saltum* action of the thermometer.

The effect of changes in the nature of the ground-surface beneath the instrument and in other objects in the vicinity cannot be readily eliminated. They have been reduced to a minimum, however, by placing the thermometer in the centre of an open space on a stand 4 feet high.

The antecedent probability that the variations in the absorptive power of the atmosphere must be very considerable is great, for, even if we have nothing else to go upon but the observations in Table I., these indicate that the total absorption is almost as great in June, when the incident rays at noon are nearly vertical, as in December, when the sun rises only 40° above the horizon. To estimate the absorbing power, it is necessary to make some assumption regarding the manner in which it varies with the thickness of the atmosphere traversed by the rays. The only simple formula yet proposed which gives results in fair accord with observations made on a clear day is that of Ponillet. This formula, it is true, applies in strictness only to radiation of one definite kind, because the atmospheric absorption is selective; and Langley* has shown, by a hypothetical example, that the approximate constancy of absorption indicated by applying the formula to observations made on the same day at the most various angles of obliquity may co-exist with an error of

* Zeitsch. d. Oest. Gesellsch. für Met., B. xx, S. 86.

nearly 50 per cent. in the deduced coefficient. Nevertheless, since it is impossible in practice to apply the method of prismatic analysis to all the very numerous actinometric observations which are required to prove the constancy or otherwise of the sun's radiation, and since the results of such an analysis must necessarily be vitiated to some extent by the selective absoption of the prism, some simple formula must be used and that of Ponillet is the best hitherto suggested. Even if the atmospheric absorption and consequently the radiation before it enters the atmosphere, as determined by this formula, be both much less than they ought to be, their variations from day to day or from month to month deduced by means of the formula must be in the same direction as they are in reality.

Ponillet's formula is $r = Ap^e$, where r is the observed heating effect, A the effect undiminished by atmospheric absorption, p the diathermancy or transmission coefficient, and e the thickness of the atmosphere traversed by the rays. Table II. gives the values of e which have been employed in reducing the Lucknow observations. They have been calculated to a first approximation only, that is to say, they are equal to the secants of the sun's zenith distance at the hours of observation.

TABLE II.—*Atmospheric Thickness at Lucknow, Latitude* 26° 50′ *N.*

Date.	Hours of observation, Mean Time.								
	8	9	10	11	12	13	14	15	16
January 7th	4·44	2·52	1·89	1·62	1·53	1·59	1·81	2·33	3·86
14th	4·38	2·49	1·85	1·58	1·50	1·54	1·75	2·23	3·38
21st	4·29	2·43	1·81	1·55	1·46	1·50	1·69	2·13	3·23
28th	4·15	2·34	1·75	1·49	1·41	1·44	1·62	2·01	3·06
February 7th	3·79	2·21	1·62	1·43	1·35	1·38	1·54	1·89	2·80
14th	3·55	2·12	1·61	1·38	1·30	1·33	1·47	1·81	2·61
21st	3·25	2·00	1·54	1·33	1·25	1·28	1·42	1·74	2·48
28th	2·99	1·89	1·47	1·27	1·20	1·23	1·36	1·66	2·34
March............ 7th	2·71	1·78	1·40	1·23	1·17	1·20	1·33	1·61	2·25
14th	2·51	1·69	1·34	1·19	1·13	1·17	1·29	1·57	2·17
21st	2·34	1·63	1·31	1·16	1·10	1·15	1·27	1·55	2·11
28th	2·19	1·55	1·26	1·12	1·08	1·11	1·23	1·49	2·04
April 7th	2·03	1·47	1·21	1·09	1·05	1·09	1·21	1·45	1·97
14td	1·93	1·42	1·18	1·07	1·04	1·07	1·19	1·43	1·93
21st	1·86	1·39	1·16	1·06	1·03	1·06	1·17	1·41	1·89
28th	1·80	1·36	1·14	1·04	1·01	1·05	1·16	1·39	1·86
May 7th	1·74	1·33	1·13	1·03	1·01	1·04	1·15	1·38	1·82
14th	1·71	1·32	1·12	1·03	1·00	1·04	1·15	1·36	1·79
21st	1·69	1·31	1·12	1·03	1·00	1·04	1·14	1·35	1·77
28th	1·69	1·31	1·12	1·03	1·00	1·03	1·13	1·34	1·74

Date.	Hours of observation, Mean Time.								
	8	9	10	11	12	13	14	15	16
June 7th	1·69	1·31	1·12	1·03	1·00	1·03	1·13	1·32	1·70
14th	1·70	1·32	1·12	1·03	1·00	1·03	1·12	1·31	1·69
21st	1·71	1·33	1·13	1·03	1·00	1·03	1·12	1·31	1·68
28th	1·72	1·33	1·13	1·03	1·00	1·03	1·12	1·30	1·66
September...... 7th	2·02	1·47	1·22	1·11	1·06	1·11	1·23	1·50	2·06
14th	2·06	1·50	1·24	1·13	1·08	1·13	1·27	1·56	2·20
21st	2·11	1·55	1·27	1·15	1·10	1·16	1·31	1·63	2·34
28th	2·17	1·56	1·29	1·17	1·13	1·20	1·36	1·71	2·53
October 7th	2·32	1·64	1·36	1·23	1·19	1·26	1·45	1·85	2·86
14th	2·37	1·68	1·38	1·25	1·22	1·30	1·49	1·92	3·04
21st	2·48	1·63	1·43	1·29	1·26	1·34	1·56	2·02	3·31
28th	2·60	1·80	1·47	1·33	1·30	1·39	1·62	2·13	3·60
November 7th	2·84	1·92	1·56	1·40	1·37	1·47	1·72	2·30	4·06
14th	3·04	2·01	1·62	1·46	1·42	1·52	1·79	2·40	4·33
21st	3·23	2·04	1·68	1·50	1·46	1·56	1·84	2·48	4·58
28th	3·45	2·19	1·73	1·54	1·50	1·59	1·88	2·53	4·69
December 7th	3·81	2·32	1·81	1·59	1·54	1·63	1·91	2·57	4·73
14th	4·06	2·40	1·85	1·62	1·56	1·64	1·92	2·55	4·64
21st	4·30	2·47	1·88	1·63	1·56	1·64	1·90	2·50	4·42
28th	4·45	2·51	1·89	1·63	1·56	1·62	1·87	2·44	4·19

In making reductions of actinometric observations it soon becomes evident that the atmospheric absorption varies not only from day to day, but frequently from hour to hour. In nearly every month it seems to be greater at Lucknow in the afternoons than in the forenoons, as might be anticipated from the disturbances caused by diurnal heating, evaporation, and the quantity of dust stirred up in dry weather by the diurnal winds. Besides this general and regular increase from forenoon to afternoon, there are numerous irregular changes from hour to hour, which render it very difficult to estimate fairly the true absorbing power and the incident heat. For example, if the absorbing power happens to be greater about noon than in the morning or evening, the curve representing the variation of the observed heating effect will be flatter than it should be, and the deduced value of the incident radiation will be too low; whereas, if the absorbing power be least about midday, the deduced solar constant will be too high.

To reduce errors of this kind to a minimum, I have, wherever the series of observations for the several days of a month were complete or nearly complete, taken the mean for each hour, and then deduced the constants A and p of the formula from these mean values. In other cases, I have made a graphic representation of the logarithms of the observed radiation on a scale the abscissæ of which represented the values of ε; and any observation which fell wide of the straight line indicated by the formula has been rejected.

Proceeding in this way, I have arrived at the following probable mean values of the solar radiation undiminished by absorption, and of the absorbing power of the atmosphere for vertical rays. The latter are the values of $(1-p)$ when p is defined as above.

TABLE III.—*Mean Values of the Constant of Solar Radiation in Degrees of the Black-bulb Thermometer.*

Year.	Jan.	Feb.	March	April.	May	June.	Sept.	Oct.	Nov.	Dec.	Mean of all months.	Mean of Eight months.*
1877 ...	76·1	78·2	72·7	73·3	80·4	86·6	77·6	79·8	91·1	85·5	80·1	79·6
1878 ...	78·5	90·8	88·3	85·0	92·4	95·8	?	85·4	84·6	79·2	86·7	85·5
1879 ...	76·7	77·6	80·1	92·7	99·2	85·9	77·1	74·6	71·2	69·4	80·4	80·2
1880 ...	73·2	78·6	83·3	75·9	80·6	?	80·7	79·1	68·3	70·7	76·7	76·2
1881 ...	72·4	74·0	78·1	72·2	85·7	77·5	73·9	73·6	67·6	71·7	74·7	74·4
1882 ...	75·2	79·5	78·8	81·9	78·8	73·4	70·6	68·8	67·5	71·3	74·6	75·2
1883 ...	74·4	73·0	76·6	80·9	77·8	79·7	74·9	74·9	76·1	75·7	76·4	76·2
1884 ...	74·7	74·0	74·6	82·5	82·0	77·6	77·6	73·8	78·7	76·4	77·2	77·1
Mean	75·2	78·2	79·0	80·6	84·6	82·4	76·1	76·2	75·6	75·0	78·3	78·0

TABLE IV.—*Coefficients of Atmospheric Absorption for Vertical Rays.*

Year.	Jan.	Feb.	March	April.	May.	June.	Sept.	Oct.	Nov.	Dec.
1877	·175	·194	·188	·216	·294	·342	·272	·269	·268	·255
1878	·260	·264	·269	·266	·354	·407	?	·274	·251	·230
1879	·212	·199	·226	·324	·390	·358	·312	·232	·191	·201
1880	·179	·211	·317	·265	·306	?	·256	·259	·187	·160
1881	·201	·194	·230	·255	·360	·377	·213	·233	·175	·205
1882	·199	·218	·258	·295	·302	·311	·231	·240	·228	·224
1883	·222	·224	·278	·316	·306	·319	·277	·235	·223	·216
1884	·241	·243	·245	·251	·277	·324	·272	·368	·274	·267
Mean	·211	·218	·251	·279	·326	·333	·262	·251	·225	·220

* June and September being left out.

From Table III., it appears that the variation of the solar heat from year to year has been similar to that deduced from the Allahabad observations, while the range indicated is even greater. The highest annual mean is that for 1878, when the sun spots were at a minimum, and the lowest, that for 1881 or 1882, when the spots were probably at a maximum.

Such a very distinct variation in the sun spot period must, I think, be the effect of a real variation in the emission of solar energy, but the great range of the observed inequality is probably due in part to other causes. It is evident from the means at the foot of Table II. that all the terrestrial causes of variation have not been eliminated, for, whilst these means are nearly constant for the months of September, October, November, December, and January, they are much more variable and considerably greater in the dry hot months of the year. If the excess temperature of the solar thermometer above that of the air were a true measure of the solar radiation, it should, when the observations are corrected for atmospheric absorption, give somewhat lower results for May and June than for December and January, on account of the greater distance of the sun in the former months. The opposite variation which is observed must be due to heat reflected from the bare hot ground and from the dust particles suspended in the air.

Since the bareness and hardness of the ground-surface under the instrument and the quantity of dust in the air are due to the same cause, and increase *pari passu;* it is, perhaps, justifiable to assume that the increase of the observed effect which is due to reflexion may be taken proportional to the quantity of dust. That is to say, we may put $A = \frac{S}{r^2}(1 + ad)$. In this formula A represents the mean value for any month at the foot of Table III.; S, the value this mean would have if the ground were moist and grassy, the air free from dust, and the earth at its mean distance from the sun; r the radius vector of the earth at the middle of the month; d the proportion of dust in the air; and a a coefficient which remains to be determined. The proportionate numbers for dust which I have assumed are:—

Jan.	Feb.	Mar.	Apl.	May	June	Sept.	Oct.	Nov.	Dec.
8	5	7	9	10	6	0	0	1	2

These differ somewhat from those already adopted for Allahabad, but, perhaps, represent the facts more justly. By means of the formula, with these values for d, we find:—

$$S = 73{\cdot}0^\circ$$
$$a = {\cdot}0157$$

In the month of May, therefore, the observed radiation is 15 or 16 per cent. greater than it would be if the ground were grassy and the air free from dust, other things being the same.

It follows from this that in a dry year the solar thermometer will give higher indications than in a damp one when due allowance is made for variations in atmospheric absorption. There can be little doubt that part of the great excess of the results for the latter half of 1877, the whole of 1878, and the first half of 1879, above those for subsequent years, is due to this cause; which is still better illustrated by comparing the months of March, April, and May, 1877, with the same months of 1879. In the former year the spring months were unusually showery, and, in consequence of this, the ground-surface was covered with grass, whilst in 1879 no rain fell and the ground was quite bare and dusty.

The conclusion to be drawn from this investigation seems to be that, while the results indicate a rather strong presumption in favour of the hypothesis that the emission of solar heat varies inversely with the number of sun spots, the hypothesis can only be definitely proved by observations of some kind of actinometer which is protected from reflexion and receives direct solar rays only. Probably, the form of instrument which will be found most useful is a thermopile turned by clock-work so as to face the sun and attached to a reflecting galvanometer by means of which the heating effect can be photographically recorded.

The absoption coefficients given in Table IV. are least in the cold weather months and greatest in the hot season and the rains. Since these coefficients are dependent upon the constitution of the atmosphere, it may be assumed, as it has been in my previous paper, that the constant p of Ponillet's formula is the product of three factors, α^b, β^f, and γ^d, where b is the barometric pressure, f the pressure of vapour, and d the proportionate number for dust. In strictness, b should stand for the pressure of the dry air only, but as the aqueous vapour thins out about three times as fast on ascending as it would do on the hypothesis of an independent vapour-atmosphere the pressure of the dry air is not $(b—f)$, as some suppose, but something very little less than b.

The mean values of the barometric pressure and tension of vapour observed at noon in the days given in Table I., are the following :—

	Pressure.	Vapour Tension.
January	29 + ·714 in.	·304 in.
February	·660	·281
March	·529	·374
April	·415	·406
May	·293	·568
June	·171	·674

	Pressure.	Vapour Tension.
September	·341 in.	·779 in.
October	·546	·464
November	·669	·335
December	·709	·268

By inserting these figures and those for dust above given in the formula, $log\ p = b\ log\ \alpha + f\ log\ \beta + d\ log\ \gamma$, it is found that the most probable values of the constants are :—

$$\alpha = {\cdot}99518$$
$$\beta = {\cdot}78091$$
$$\gamma = {\cdot}98924$$

These results, while confirming those already arrived at, indicate that the absorption of solar radiation by dry air is greater than I have hitherto supposed, though not nearly so great as the absorption by water vapour.

IV.—*List of the Butterflies of Calcutta and its Neighbourhood, with Notes on Habits, Food-plants, &c.*—*By* Lionel de Nice'ville.

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In the 'Entomologist's Monthly Magazine,' 1882 vol. XIX, p. 33, there is a paper by Mr. G. A. J. Rothney, entitled, "A list of the Butterflies captured in Barrackpore Park during the months of September, 1880, to August, 1881." In this list, however, only 98 species are mentioned, which probably all occur in Calcutta, the two places being but 14 miles apart, and both situated on the low-lying deltaic banks of the Hughli. I have accordingly included all those of Mr. Rothney's species which I have not myself met with in Calcutta, distinguishing them by an asterisk prefixed to the serial number.

One of the most interesting points to which my attention has been drawn in these butterflies is the occurrence of seasonal dimorphism, there being in several species an ocellated form which occurs only in the rains, the cold and dry seasonal being non-ocellated. The constancy of this phenomenon is such that I cannot help thinking there must be some physical reason for it, can it be a protective one ? The difference in the garb of the surrounding vegetation makes it little remarkable that a change should be found in the coloration of the butterflies of the two seasons, but it is difficult to see why this change should show itself in the obliteration or development of ocelli. The only hypothesis which I can suggest is, that during the rains the density of the vegetation is such